PATENT SPECIFICATION

Application Date: March 6, 1933. No. 6797/33.

419,283

Complete Left: March 6, 1934.

Complete Accepted: Nov. 6, 1934.

PROVISIONAL SPECIFICATION.

Improvements in or relating to Tap Changing Apparatus for Electric Transformers.

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C. 2, a British company, and WILLIAM WILSON and JOHN WALTER GIBSON, both of The General Electric Company Limited, Engineering Works, Witton, Birmingham, both British subjects, do hereby declare the nature of this invention to be as follows:—

This invention relates to tap changing apparatus for electric transformers, one object being the provision of cheap and simple on-load tap changing means for use in connection with relatively small loads, another object being the provision of tap changing voltage regulating arrangements suitable for effecting automatic voltage regulation of the power supplied to small loads such as occur, for instance, in rural electric power distribution systems, in which, frequently, owing to the relatively low distribution voltage and the relatively large distances over which power is transmitted the voltage at the consumer's premises is excessively low.

Tap changing apparatus for an electric transformer according to the present invention comprises a movable contact device adapted by rolling over a fixed contact device to effect the tap changing operations and means associated with the movable contact device and arranged to prevent short-circuiting of sections of transformer winding.

In one particular arrangement of tap changing apparatus for an electric transformer a movable contact device is adapted by rolling over a fixed contact device to effect the tap changing operations without short-circuiting sections of transformer winding and means influenced by a condition to be regulated are arranged automatically to effect operation of the movable contact device.

The transformer is an air cooled autotransformer, suitable for supplying a load, say, of 6 KW., and a torque motor is connected with the power supply on the side of the transformer nearer the power supply and is adapted to operate the movable contact device for the purpose of regulating the voltage on the side of the transformer nearer the load.

The contact devices are of arcuate form and the fixed contact device includes a number of segments for connection respectively to the different tappings of the transformer winding, whilst the movable contact device is provided with twice as many segments as the fixed contact device, pairs of neighbouring segments of the movable contact device co-operating with a particular segment of the fixed contact device and being connected to opposite ends of a preventive choke coil. The load is connected with one end of the choke coil.

Actually the supply is a three phase power supply, and the windings of the three phases of the transformer are star connected and with each phase is associated a fixed contact device and a movable contact device. The fixed contact device includes, say, ten segments each connected to a separate tapping point on the associated phase of the transformer winding. Each tap gives a voltage variation, for instance, of about one per cent. The corresponding phase of the supply line is connected to the innermost tapping point although it may sometimes be preferred to connect the said phase to some other point in the said phase of the transformer winding. The movable contact device includes twenty segments of approximately half the width of the segments of the fixed contact device and with each of the latter segments are associated a pair of the former segments. Co-operating teeth or equivalent means may be provided for ensuring that the segments of the movable contact device always remain in proper spacial relationship relatively to the segments of the fixed contact device. The alternate segments of the movable contact device are, as previously indicated, respectively connected to opposite terminals of the preventive choke coil. There are of course three choke coils, one for each phase.

The fixed contact devices of the different phases subtend angles of about 60°, for example, and are disposed symmetric-

[Price 1/-]

Price 4s 6d

ally on a circle having its centre on the axis of rotation of the torque motor. The latter has keyed to its shaft a disc on which the movable contact devices are similarly and symmetrically mounted. Conveniently the segments of each movable contact device are mounted on a sector shaped arm pivotally mounted at its centre or inner end to the centre of a flat spring anchored at its ends to the aforesaid disc. The radius of curvature of the arc of the movable contact device is less than that of the fixed contact device and the arrangement is such that the spring presses the operative contact or pair of contacts of the movable contact device firmly against the co-operating segment of the fixed contact device.

The torque motor is a three phase squirrel cage motor with ball bearings which operates against the force of a spring or springs or other suitable means designed for the purpose of giving the desired voltage regulation. Since the motor is connected to the supply on the side of the transformer remote from the load, the voltage applied to the motor is not regulated by the tap changing apparatus and hunting is therefore avoided. If desired, a damping or retarding device may be associated with the shaft of the motor.

The spring or other suitable means is so designed, having regard to the torque voltage characteristics of the motor, that in operation the voltage applied to the load remains approximately constant as the supply voltage varies in value within the range of operation of the regulator.

If the regulator is in the position corresponding to the highest supply voltage the first, or innermost tap of a transformer phase winding is connected to the load through the first segment of the associated fixed contact device, the first contact of the co-operating movable contact device and the preventive choke of that phase. If the supply voltage falls slightly the second segment instead of or as well as the first segment of the movable contact device engages the first segment of the fixed contact device so that the preventive choke is short-circuited or cut out and the voltage drop therein disappears. If the supply voltage falls further, the third segment of the movable contact device will engage the second segment of the fixed contact device, while the second segment of the movable contact device is in engagement with the first segment of the fixed contact device. The section of transformer winding between the first and second tapping points is not short-circuited, however, since the preventive choke is connected across that section. As the voltage falls still further the second segment of the movable contact device disengages the first segment of the fixed contact device, so that the second tap of the transformer winding is connected through the preventive choke to the load. This position of the movable contact device corresponds to the above mentioned first or highest voltage position of the device and as the supply voltage continues to fall the sequence of operation just described is repeated in connection with the succeeding segments of fixed and movable contact devices. If, for instance, with an average load on the transformer the voltage drop in a preventive choke, when the latter is operatively in series with the load, is equal to half the voltage difference between adjacent voltage taps, then under the load conditions in question there will be as many equal voltage steps as there are segments of a movable contact device.

The segments of the contact devices are constructed in a suitable manner and of suitable material in order to give reliable operation and long life.

In certain instances, for example, when the supply system is single phase the torque motor will be of the split phase type. The regulator is conveniently mounted adjacent to the auto-transformer, for example, within the same casing.

It will be seen that the above described arrangement in accordance with the invention comprises on-load voltage regulating means and a torque motor connected with the power supply on the side of the voltage regulating means remote from the load and adapted automatically to operate the said voltage regulating means.

Dated the 6th day of March, 1933.

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

COMPLETE SPECIFICATION.

Improvements in or relating to Tap Changing Apparatus for Electric Transformers.

We, THE GENERAL ELECTRIC COMPANY LIMITED, of Magnet House, Kingsway, London, W.C. 2, a British company, and WILLIAM

WILSON and JOHN WALTER GIBSON, both of The General Electric Company Limited, Engineering Works, Witton, Birmingham, both British subjects, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to tap changing apparatus for electric transformers, one object being the provision of cheap and simple on-load tap changing means for use in connection with relatively small loads, another object being the provision of on-load tap changing voltage regulating arrangements suitable for effecting automatic voltage regulation of the power supplied to small loads such as occur, for instance, in rural electric power distribution systems, in which, frequently, owing to the relatively low distribution voltage and the relatively large distances over which power is transmitted the voltage at the consumer's premises is excessively low.

On-load tap changing apparatus for an electric transformer according to the present invention comprises a movable contact device adapted, by rolling over a fixed contact device, to effect the tap changing and means, associated with the movable contact device, and arranged to prevent short-circuiting of sections of transformer winding.

In one particular arrangement of tap changing apparatus for an electric transformer a movable contact device is adapted by rolling over a fixed contact device to effect the tap changing without short-circuiting sections of transformer winding and means influenced by the voltage to be regulated are arranged to effect automatically operation of the movable contact device.

A torque motor may be connected with the power supply on the side of the transformer nearer the power supply and may be adapted to operate the movable contact device for the purpose of regulating the voltage on the side of the transformer nearer the load.

Preferably the contact devices are of arcuate form and the fixed contact device includes a number of segments for connection respectively to the different tappings of the transformer winding, whilst the movable contact device is provided with twice as many segments as the fixed contact device, pairs of neighbouring segments of the movable contact device co-operating with a particular segment of the fixed contact device and being connected to opposite ends of a choke coil. The load is connected with one end of the choke coil.

One arrangement in accordance with the invention will now be described by way of example with reference to the accompanying diagrammatic drawing which shows the arrangement as applied to a three-phase auto-transformer.

In the drawing the supply is shown as a three phase power supply, over bus bars 1, and the windings 2 of the three phases of the auto transformer are star connected and with each phase is associated a fixed contact device 3 and a movable contact device 4. The fixed contact device 3 includes, say, ten segments each connected to a separate tapping point on the associated phase of the transformer winding 2. Each tap gives a voltage variation, for instance, of about one per cent. The corresponding phase of the supply line 1 is connected to the innermost tapping point, although it may sometimes be preferred to connect the said phase to some other point in the said phase of the transformer winding. Each movable contact device 4 includes twenty segments of approximately half the width of the segments of the fixed contact device 3 and with each of the latter segments are associated a pair of the former segments. Co-operating teeth or equivalent means may be provided for ensuring that the segments of the movable contact device always remain in proper spacial relationship relatively to the segments of the fixed contact device. The alternate segments of the movable contact device are respectively connected to opposite terminals of a preventive choke coil 5, over lines 6, 7. There are of course three choke coils 5, one for each phase.

The fixed contact devices 3 of the different phases subtend angles of about 60° and are disposed symmetrically on a circle having its centre on the axis of rotation of a torque motor 8. The latter has keyed to its shaft 9 a disc 11, on which the movable contact devices 4 are similarly and symmetrically mounted. The segments of each movable contact device 4 are mounted on a sector shaped arm 10 pivotally mounted at its centre or inner end to the centre of a flat spring 12 anchored at its ends on pillars 13, on the aforesaid disc 11. The radius of curvature of the arc of each movable contact device 4 is less than that of the associated fixed contact device 3 and the arrangement is such that the spring 12 presses the operative contact or pair of contacts of the movable contact device 4, firmly against the co-operating segment of the fixed contact device 3.

The torque motor 8 is a three phase squirrel cage motor with ball bearings

3-Phase-Kurzschluss-läufermotor mit Kugellagern

which operates against the force of a spring 14 or other suitable means. The motor 8 is connected to the supply 1 by leads 15. The load circuit bus-bars 16, are connected by lines 17 to the lines 7 connected to one set of the alternate contacts of the moving contact device 4. Since the motor 8 is connected to the supply 1 on the side of the transformer remote from the load, the voltage applied to the motor is not regulated by the tap changing apparatus and hunting is therefore avoided.

The spring 14 or other suitable means is so designed, having regard to the torque voltage characteristics of the motor 8, that in operation the voltage applied to the load remains approximately constant as the supply voltage varies in value within the range of operation of the regulator.

If the regulator is in the position corresponding to the highest supply voltage, which is the extreme position opposite to that shown in the drawing, the first, or innermost tap of each transformer phase winding 2, is connected to the load 16 through the first segment of the associated fixed contact device 3, the first contact of the co-operating movable contact device 4 and the preventive choke 5. If the supply voltage falls slightly the second segment instead of or as well as the first segment of the movable contact device 4 engages the first segment of the fixed contact device 3 so that the preventive chokes 5 are short-circuited or cut out and the voltage drop therein disappears. If the supply voltage falls further, the third segment of the movable contact device 4 will engage the second segment of the fixed contact device 3, while the second segment of the movable contact device 4 is in engagement with the first segment of the fixed contact device 3. The section of the transformer windings 2 between the first and second tapping points are not short-circuited, however, since the preventive choke 5 is connected across that section. As the voltage falls still further the second segment of the movable contact device 4 disengages the first segment of the fixed contact device 3, so that the second taps of the transformer windings are connected to the load through the chokes 5. As the supply voltage continues to fall the sequence of operation just described is repeated in connection with the succeeding segments of the fixed and movable contact devices, until the position corresponding to the lowest supply voltage is reached, which is the position shown.

The segments of the contact devices 3 and 4 are constructed in a suitable manner and of suitable material in order to give reliable operation and long life.

In certain instances, for example, when the supply system is single phase the torque motor will be of the split phase type. The regulator is conveniently mounted adjacent to the auto-transformer, for example, within the same casing.

It will be seen that the above described arrangement in accordance with the invention comprises on-load voltage regulating means and a torque motor connected with the power supply on the side of the voltage regulating means remote from the load and adapted automatically to operate the said voltage regulating means.

In an alternative construction, similar to that described with reference to the drawing, the torque motor is arranged to drive the shaft by which the moving contacts are operated through gearing, the controlling force of the regulator (i.e. the spring 14) being then exerted on the torque motor shaft. In this manner the effect of the friction at the rolling contacts on the sensitivity of the apparatus is reduced.

Moreover in an arrangement where the torque motor is connected on the load side of the auto-transformer, the controlling force thereon would have to be constant, and may be operated for example by gravity operated means. Damping means are then included to reduce hunting.

The arrangement may of course be modified to employ a series boosting transformer in place of the auto-transformer in which case the primary current of the boosting transformer would be controlled by the regulator and the secondary of the boosting transformer would be in series with the load circuit.

Having now particularly described and ascertained the nature of our said invention, and in what manner the same is to be performed, we declare that what we claim is:—

1. On-load tap changing apparatus for an electric transformer comprising a movable contact device adapted by rolling over a fixed contact device to effect the tap changing and means associated with the movable contact device and arranged to prevent short-circuiting of sections of transformer winding.

2. On-load tap changing apparatus for an electric transformer comprising a movable contact device adapted by rolling over a fixed contact device to effect the tap changing without short-circuiting sections of the transformer winding and means influenced by the voltage to be regulated and arranged automatically to

effect operation of the movable contact device.

3. Voltage regulating means comprising an auto-transformer and on-load tap changing apparatus associated with the transformer and including a movable contact device adapted by rolling over a fixed contact device to effect the tap changing without short-circuiting sections of the transformer winding and a torque motor connected with the power supply on the side of the transformer nearer the power supply and adapted to operate the movable contact device for the purpose of regulating the voltage on the side of the transformer nearer the load.

4. Voltage regulating means comprising an auto-transformer and on-load tap changing apparatus associated with the transformer and including a movable contact device adapted by rolling over a fixed contact device to effect the tap changing without short-circuiting sections of the transformer winding, a torque motor connected with the supply on the side of the transformer nearer the load and adapted to operate the movable contact device for the purpose of regulating the voltage on the side of the transformer nearer the load, damping means being associated with the torque motor whereby hunting thereof is substantially eliminated.

5. Voltage regulating means comprising a series boosting transformer, the secondary of which is connected in series with the load, on-load tap changing apparatus associated with the primary of the series boosting transformer and including a movable contact device adapted by rolling over a fixed contact device to effect the tap changing operation without short-circuiting sections of the transformer winding, and a torque motor connected with the power supply on the side of the boosting transformer nearer the power supply and adapted to operate the movable contact device for the purpose of regulating the voltage on the side of the boosting transformer near the load.

6. Voltage regulating means as claimed in any preceding claim wherein the torque motor is adapted to operate the movable contact device through gearing whereby the effect of friction, at the contact faces of the fixed and moving parts of the tap changing operation, on the sensitivity of the arrangement is substantially reduced.

7. Voltage regulating means as claimed in any preceding claim, wherein the contact devices are of arcuate form and the fixed contact device includes a number of segments for connection respectively to the different tappings of the transformer winding, whilst the movable contact device is provided with twice as many segments as the fixed contact device, pairs of neighbouring segments of the movable contact device co-operating with a particular segment of the fixed contact device and being connected to opposite ends of a choke coil.

8. Voltage regulating means as claimed in Claim 7, wherein the load is connected with one end of the choke coil.

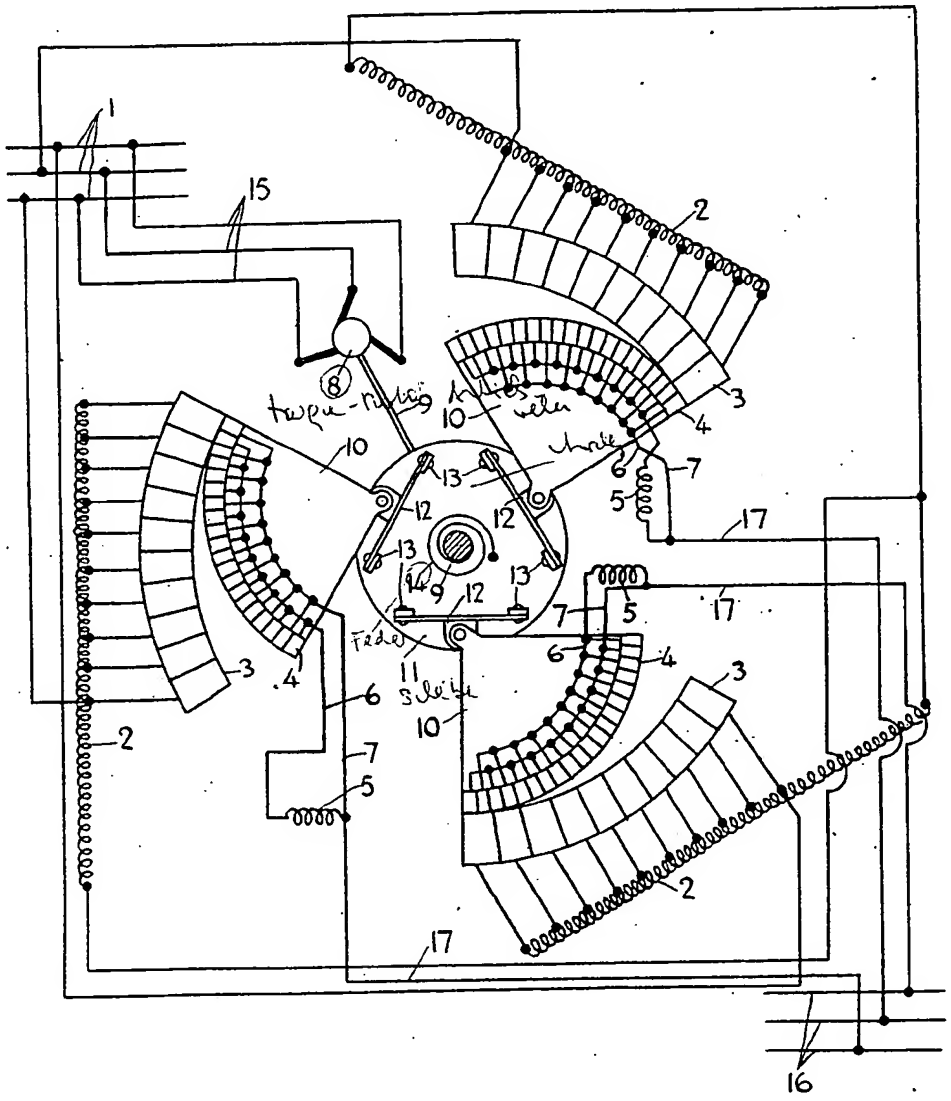
9. Voltage regulating means substantially as hereinbefore described with reference to the accompanying drawing.

Dated the 6th day of March, 1934.

For the Applicants,
A. C. PRICE,
Chartered Patent Agent.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1934.

torque motor = Drehmomentantrieb, Motor mit konstantem Drehmoment, Drehmomentmotor



Malby & Sons, Photo-Lith.

Fig.: Wechselgetriebe System 2 1